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EFFECT OF FOOD ON MILK.

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Experiments in Feeding for Milk and Butter.

A. H. WOOD.

During the winter of 1891 and 1892 experiments were carried on to determine the effect of some of the coarse fodders upon the quantity and quality of milk, and also upon the resulting butter product.

Ten cows were selected from the station herd and grouped as indicated in the following table. The table also shows the breed, length of time since calving, and approximate weight.

	Name.	Breed.	Last calf.	Weight.
Group 1.	Duchess.	Durham.	Nov. 9, '91.	1,100 pounds.
	Duchess, 2d.	Durham.	Dec. 22, '91.	1,000 "
Group 2.	Princess Leto.	Jersey.	Oct. 22, '91.	900 "
	Pilot's Lily.	Jersey.	Sept. 19, '91.	1,000 "
Group 3.	Frost.	Ayrshire.	Sept. 24, '91.	900 "
	Maramee.	Holstein.	Oct. 14, '91.	1,200 "
Group 4.	Chinchilla, Jr.	Ayrshire.	July 21, '91.	1,000 "
	Frost, Jr.	Ayrshire.	July 17, '91.	900 "
Group 5.	Maid of Arlis.	Ayrshire.	June 23, '91.	1,000 "
	Nora, 2d.	Durham.	June 21, '91.	1,200 "

During the first two weeks all of the cows were fed upon the following ration per 1,000 pounds live weight:

			Digestible	
			Albuminoids.	Non-albuminoids.
Ensilage	50 lbs., furnishing		.73 lbs.	7.40 lbs.
Mixed hay	5 "	"	.24 "	2.24 "
Oat hay	5 "	"	.18 "	2.38 "
Middlings	1 lbs.	" .22	.96	
Gluten	1 lbs.	5 lbs. " .56	1.30 " 1.03	2.69 "
Cotton-seed meal	1 lbs.	" .52	.70	
		2.45		14.71

This ration has a nutritive ratio of 1 to 6, or, to state the matter more fully, it furnishes one pound of digestible albuminoids to six pounds of digestible non-albuminoids.

Analyses of the milk of the different cows were made daily, and in the following tables the daily yield of milk and its per cent of fat are averaged for the entire period.

At the close of the preliminary period, group 1 had clover hay substituted for mixed and oat hay; in period 3, mixed hay took the place of clover; and in period 4, they returned to the preliminary ration.

Table 1 shows how these changes affected the supply of albuminoids and non-albuminoids, and hence the nutritive ratio; also the average daily yield of milk, and its per cent of fat.

TABLE 1.

	Period.	Ensilage.	Mixed hay.	Oat hay.	Clover hay.	Mixed grain.	Albuminoids.	Non-albuminoids.	Nutritive ratio.	Average daily yield of milk.	Average per cent of fat.	Per cent of casein.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		lbs.		
Duchess	1	55	5½	5½	....	5½	2.61	16.17	1:6.0	34.00	3.91	2.90
	2	55	....	....	11	5½	3.05	15.88	1:5.2	35.10	3.94	3.00
	3	55	11	....	....	5½	2.63	16.33	1:6.2	32.99	4.03	3.00
	4	55	5½	5½	....	5½	2.69	16.17	1:6.0	30.17	4.12	3.41
Duchess, 2d	1	50	5	5	....	5	2.45	14.71	1:6.0	39.11	4.03	2.64
	2	50	....	....	10	5	2.78	14.45	1:5.2	36.44	3.91	2.67
	3	50	10	....	....	5	2.40	14.86	1:6.2	35.79	3.78	2.67
	4	50	5	5	....	5	2.45	14.71	1:6.0	35.05	3.66	2.81

Duchess, 2d, was slightly off feed during the last few days of period 1, and the first few days of period 2, which will explain the rather sharp decrease in her yield of milk.

Group 2 received vetch hay in period 2; in period 3, mixed hay replaced the vetch hay, and the quantity of both ensilage and dry fodder was reduced one fifth, corn meal taking its place. Table 2 shows the variations in the rations of group 2, and the results.

TABLE 2.

	Period.	Ensilage.	Mixed hay.	Oat hay.	Vetch hay.	Mixed grain.	Corn meal.	Albuminoids.	Non-albuminoids.	Nutritive ratio.	Average daily yield of milk.	Average per cent of fat.	Caseine per cent.
		lbs.	lbs.	lbs.	lbs.	bs.	lbs.	lbs.	lbs.		lbs.		
Princess Leto.....	1	45	4½	4½	...	4½	....	2.21	13.24	1:6.0	23.18	5.23	3.45
	2	45	...	....	9	4½	....	2.66	12.47	1:4.7	22.76	5.32	4.16
	3	36	7½	...	....	4½	2¼	2.14	12.79	1:6.0	22.74	5.16	3.53
	4	45	4½	4½	....	4½	....	2.21	13.24	1:6.0	21.13	5.23	3.22
Pilot's Lily.....	1	50	5	5	....	5	....	2.45	14.71	1:6.0	19.73	5.19	3.65
	2	50	....	....	10	5	....	2.95	13.86	1:4.7	19.58	5.36	3.77
	3	40	8	....	....	5	2½	2.37	14.19	1:6.0	20.05	5.22	3.73
	4	50	5	5	....	5	....	2.45	14.71	1:6.0	18.75	5.29	3.69

The only trial of vetch hay was made with this group, and the result shows it to be equal to, or better than the mixture of hay and oats. Vetch hay is so rich in albuminoids that it might be combined with advantage with foods poorer in albuminoids than were used in this trial. Reference to the table will show that the substitution of it, in place of mixed hay and oat hay narrowed the nutritive ratio from 1 : 6 to 1 : 4.7, so that we cannot say that the result fairly exhibits its comparative value as a food.

In period 3 the substitution of corn meal for a part of the coarse fodder gave good results in that it not only held in check the natural decrease in yield of milk, but caused a slight increase. It would seem to indicate that when prices of grain and dairy products are in favorable relation, a heavier grain ration than that ordinarily fed by our farmers may be fed to good advantage.

Group 3 in period 2 received mixed hay. In period 3, corn meal was substituted for the gluten and cotton-seed meal, thus nearly approaching a ration fed by a great number of our New Hampshire farmers.

TABLE 3.

	Period.	Ensilage.	Mixed hay.	Oat hay.	Middlings.	Gluten.	Cotton-seed meal.	Corn meal.	Albuminoids.	Non-albuminoids.	Nutritive ratio.	Average daily yield of milk.	Average per cent of fat.	Casein per cent.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		lbs.		
Frost.....	1	45	4½	4½	1½	1½	1½	....	2.21	13.24	1:6.0	30.50	3.95	....
	2	45	9	....	1½	1½	1½	....	2.15	13.36	1:6.2	31.52	3.87	....
	3	45	9	....	1½	....	....	3	1.41	13.95	1:9.8	25.64	3.82	....
	4	45	4½	4½	1½	1½	1½	....	2.21	13.24	1:6.0	24.42	3.84	....
Maramee.....	1	60	6	6	2	2	2	....	2.94	17.65	1:6.0	30.45	3.08	2.66
	2	60	9	....	2	2	2	....	2.87	17.82	1:6.2	31.31	3.08	2.84
	3	60	9	....	2	....	....	4	1.89	18.61	1:9.8	28.32	3.04	2.63
	4	60	6	6	2	2	2	....	2.94	17.65	1:6.0	26.39	3.08	2.58

A study of table 3 will show the reader how radical a change in the relation between albuminoids and non-albuminoids is brought about by so simple a change in foods as the substitution of corn meal for gluten and cotton-seed meal. The digestible albuminoids are reduced one third, while the digestible non-albuminoids are slightly increased and the nutritive ratio widened in consequence from 1 : 6.2 to 1 : 9.8. The effect of such a change in cows giving milk was shown in a sharp falling off in the yield of milk. To show how great this shrinkage was, we will make a comparison with the eight cows in groups 1, 2, 4, and 5 :

Daily average yield of eight cows in groups 1, 2, 4, and 5 during period 2 . . . . . 25.71 lbs.

Daily average yield of eight cows in groups 1, 2, 4, and 5 during period 3 . . . . . 24.73 lbs.

Average shrinkage . . . . . .98 lbs.

Daily average yield of two cows in group 3 during period 3 . . . . . 31.41 lbs.

Daily average yield of two cows in group 3 during period 3 . . . . . 26.98 lbs.

Average shrinkage . . . . . 4.43 lbs.

Or, stated in another way, the cows in the four groups fed upon normal rations during periods 2 and 3 gave three and eight tenths per cent less milk per day during period 3 than during period 2, while the two cows in group 3 fed upon what ought to be considered an abnormal ration gave during period 3 fourteen and one tenth per cent less milk during period 3 than during period 2. If the two cows in group 3 had shrunk in the same proportion as the cows in the other four groups, their shrinkage would have been 1.19 pounds, leaving a shortage of 3.24 pounds, or a quart and a half of milk per cow directly chargeable to wrong feeding. We do not wish in this connection to be understood as condemning corn meal as a dairy food. It is a very valuable food when fed in connection with fodders rich in albuminoids, as clover hay, such grains as peas and oats or the highly nitrogenous by-fodders, cotton-seed, linseed, and gluten meals; but to make it the chief grain food with coarse fodders furnishing ample supplies of non-albuminoids but deficient in albuminoids, is simply inexcusable.

Coming now to group 4, we find the changes to have been to oat hay in period 2, in period 3 oat hay is replaced by clover hay, and in period 4 they returned to the original ration. Table 4 shows the results from these changes.

TABLE 4.

	Period.	Ensilage.	Mixed hay.	Oat hay.	Clover hay.	Mixed grains.	Albuminoids.	Non-albuminoids.	Nutritive ratio.	Average daily yield of milk.	Average per cent of fat.	Casein per cent.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.		lbs.		
Chinchilla, Jr	1	50	5	....	....	5	2.45	14.71	1:6.0	17.80	4.32	3.17
	2	50	....	10	....	5	2.51	14.57	1:5.8	17.11	4.48	3.57
	3	50	....	....	10	5	2.78	14.45	1:5.2	17.17	4.37	3.70
	4	50	5	....	....	5	2.45	14.71	1:6.0	16.52	4.19	3.5
Frost, Jr	1	45	4½	....	....	4½	2.21	13.24	1:6.0	23.65	4.02	2.96
	2	45	....	9	....	4½	2.26	13.12	1:5.8	23.79	4.14	2.93
	3	45	....	....	9	4½	2.50	13.00	1:5.2	24.12	4.08	3.15
	4	45	4½	....	....	4½	2.21	13.24	1:6.0	21.53	3.78	3.04

Group 5 changed at the beginning of period 2 from the preliminary ration to one containing only one half as much ensilage, receiving in its place corn stover and corn and cob meal. The stover and meal fed were from corn exactly like that put in the silo, and as nearly as we could calculate the amount fed was equivalent to the reduction in ensilage. In period 3 the change from ensilage to dry stover and corn and cob meal was made complete. In period 4 ensilage replaced the stover and meal.

TABLE 5.

	Period.	Ensilage.	Mixed hay.	Oat hay.	Sanford corn stover.	Mixed grains.	Sanford corn and cob meal.	Albuminoids.	Non-albuminoids.	Nutritive ratio.	Average daily yield of milk.	Average per cent of fat.
		lbs.	lbs.	lbs.	lbs.	lbs.		lbs.	lbs.		lbs.	
Maid of Arlis.....	1	50	5	5	....	5	....	2.45	14.71	1:6	22.98	4.07
	2	25	5	5	4	5	$1\frac{5}{8}$	2.45	14.71	1:6	22.30	4.11
	3	....	5	5	8	5	$3\frac{1}{4}$	2.45	14.71	1:6	18.36	4.34
	4	50	5	5	....	5	....	2.45	14.71	1:6	16.69	4.11
Nora, 2d.....	1	60	6	6	....	6	....	2.94	17.65	1:6	26.37	4.24
	2	30	6	6	5	6	2	2.94	17.65	1:6	28.41	4.18
	3	....	6	6	10	6	4	2.94	17.65	1:6	26.66	4.26
	4	60	6	6	....	6	....	2.94	17.65	1:6	26.52	4.13

We have assumed that the digestible nutrients furnished in the rations fed during periods 2 and 3 were equal in amount to those fed during periods 1 and 4, but they may not have been so exactly. The reduction in the amount of ensilage fed in period 2 was accompanied with a slight shrinkage in milk in the case of Maid of Arlis, not, however, more than would have been expected if her ration had remained as before; while in the case of Nora, 2d, there was a positive increase of one quart per day. The effect of changing wholly to dry food in period 3 was a shrinkage in the yield of Maid of Arlis of nearly two quarts and in Nora, 2d, of nearly one quart per day. The return to ensilage in period 4 kept the yield of Nora, 2d, almost constant, while that of Maid of

Arlis continued to decrease, but not as rapidly as in the preceding period. We cannot draw any definite conclusions from these results, as there is uncertainty regarding the equivalence of the different rations; but they may serve to indicate that the most profitable use of ensilage may not consist in making it the almost exclusive coarse fodder in a milk ration.

We may now consider the relative effects of clover, vetch, oat, and mixed hays when fed in combination with such foods as were used in these experiments. The data are not very extensive, but we will present them at this time trusting that they will be of value to some of our farmers. Referring to the preceding tables, we gather the following results:

CLOVER.

	Gain. lbs.	Loss. lbs.
Duchess, period 2, mixed and oat hay to clover	1.10	
Duchess, 2d, " " " " "		2.65
Chinchilla, Jr., period 3, oat hay to clover	.06	
Frost, Jr., " " " "	.33	
Duchess, period 3, clover to mixed hay		2.11
Duchess, 2d, " " " "		.65
Chinchilla, Jr., period 4, clover to mixed and oat hay		.65
Frost, Jr., " " " " "		2.59

With one exception, changing *to clover* not only checked the natural decrease in milk yield, but gave a slight increase. In the exceptional case of Duchess, 2d, it is to be remembered that she went off feed just at the close of period 1, so that the shrinkage in her case cannot be charged up against clover. Again the changes *from clover* are in every case accompanied by a loss, in two instances, Duchess and Frost, Jr., surely beyond the natural decrease. We can safely say that clover certainly demonstrated its superiority over the other hays as a supplement to ensilage.

VETCH.

	Gain. lbs.	Loss. lbs.
Princess Leto, period 2, mixed and oat hay to vetches		.42
Pilot's Lily, " " " " "		.15
Princess Leto, period 3, vetch hay to mixed hay and corn meal		.02
Pilot's Lily, period 3, vetch hay to mixed hay and corn meal	.47	

The vetch hay certainly proved itself to be a good food, yet there can be little doubt but that it would show to greater advantage in combination with foods of a wider nutritive ratio, since 1 : 4.7 is narrower than common experience has shown to be most profitable.

MIXED HAY.

	Gain. lbs.	Loss. lbs.
Duchess, period 3, clover to mixed hay		2.11
Duchess, 2d, " " " "		.65
Frost, period 2, mixed and oat hay to mixed hay	1.02	
Maramee, period 2, mixed and oat hay to mixed hay	.86	
Duchess, period 4, mixed hay to mixed and oat hay		2.82
Duchess, 2d, " " " " "		.74

Whenever there was a change from mixed and oat hay to the mixed hay alone, there was an increase in milk yield, and when the changes were from mixed hay to mixed and oat hay, there was a loss; so it would seem that the mixed hay (timothy and clover) gave better results than did oat hay, although in one instance (Frost, Jr., period 2) there was a gain from a change from mixed and oat hay to the oat hay alone.

OAT HAY.

	Gain. lbs.	Loss lbs.
Chinchilla, Jr., period 2, mixed and oat hay to oat hay		.69
Frost, Jr., period 2, mixed and oat hay to oat hay	.14	
Chinchilla, Jr., period 3, oat hay to clover	.06	
Frost, Jr., " " " "	.33	

While oat hay gave rather less favorable results than did the other fodders, it nevertheless makes a fair showing.

CHANGES IN THE QUALITY OF MILK.

What was the effect of these various changes in the character of the food upon the quality of the milk? To the consideration of those who believe that the fat contents of milk can be materially varied by changes in the character of the food given cows, I would commend an inspection of the average percentages of fat as given in the preceding tables. That there are variations in the amount of fat in the milk when we compare period with period, is true, but it does not follow that these variations are due to the source of the cow's food.

It has been proven that a ration containing about two and one half pounds of digestible albuminoids and about thirteen and one half pounds of digestible non-albuminoids, is essential to maintain a cow, giving milk and weighing one thousand pounds, in a normal condition — that is, to keep her in good bodily condition and maintain a full flow of milk. Such a ration we may well call a normal or balanced ration. These figures are not arbitrary, within reasonable limits they may be varied without serious results, and perhaps sometimes with positive advantage. But suppose we give a ration containing only one and one half pounds of digestible albuminoids and a proper or greater amount of non-albuminoids. We are now giving the cow a ration that does not contain within it an amount of albuminoids sufficient to meet the demands of nature. She is certainly now in an unnatural or abnormal condition, and we

may properly speak of such rations as abnormal or unbalanced rations. May we not expect abnormal results from such feeding? We know that other abnormal conditions produce unnatural results.

I have frequently been asked the question, "If I feed a poorer ration, as straw without much grain, my cows will give milk poorer in fat, will they not?" I have answered that, in my opinion, it depended almost wholly upon the tendency of the cow, it would probably remain practically unchanged, but it might be either richer or poorer. My belief is simply this, that so long as a cow is fed upon a well balanced ration, composed of foods agreeable to her taste, the variations in the per cent of fat in her milk are mainly due to other circumstances than the sources from which the nutrients in her ration are derived.

Begin with table 1, and follow the changes through. With Duchess we find a small but nearly constant increase, while Duchess, 2d, shows a steady decrease. Duchess, 2d, was fresh in milk and, as before stated, was off feed early in the experiment. Princess Leto and Pilot's Lily made an increase in period 2, followed by a decrease in period 3, and an increase in period 4. Does the increase of one, or two tenths of one per cent, in period 2, and a decrease of one seventh of one per cent in period 3, prove, or even indicate that vetch hay has a tendency to cause cows to give richer milk, or that corn meal has a tendency to produce poorer milk? Is it not more probable that these slight changes were induced by the unusually narrow ration followed by the change to a heavy grain ration? Again, does the decrease in Frost and Maramee in period 3, of four or five hundredths of one per cent, prove that corn meal produces poor milk; or does it show that, in spite of the radical change in the food, these two cows continued to maintain the *quality* of their milk at the expense of *quantity?* To show the matter more plainly, I insert the daily record of Maramee for periods 2 and 3.

Daily record of Maramee, period 2. *Nutritive ratio,* 1 : 6.2.

1st week, yield of milk...	30.38	30.38	31.69	29.63	31.44	31.56	32.00	Av'ge, 31.01
2d week, yield of milk...	31.68	32.00	31.88	31.63	30.87	31.25	31.81	" 31.59
1st week, per cent of fat..	3.13	3.05	2.96	2.88	3.10	3.17	3.22	" 3.07
2d week, per cent of fat .	3.13	3.00	3.00	3.09	3.09	3.13	3.22	" 3.08

Daily record of Maramee, period 3. *Nutritive ratio,* 1 : 9.8.

1st week, yield of milk...	30.63	30.31	30.50	30.06	29.57	28.44	27.31	Av'ge, 29.46
2d week, yield of milk...	27.81	27.00	27.50	27.25	27.12	27.50	25.50	" 26.38
1st week, per cent of fat..	3.09	3.17	2.88	2.92	2.96	2.96	2.92	" 2.99
2d week, per cent of fat..	3.00	3.05	3.13	3.13	3.17	3.00	3.22	" 3.10

It is seen that in period 2, when the change was from mixed and oat hay to mixed hay alone, that there was a constant increase in milk, but no practical change in the fat contents. There are fluctuations from day to day, but these balance each other so nearly that the averages of the first and second weeks are nearly identical.

In period 3, with the substitution of corn meal for gluten and cotton-seed meal, the division of the period into weeks makes a different showing. We have first a falling off in quantity and quality of milk, followed by a still greater loss in quantity and increase in fat. If we compare the last weeks in the two periods, we see that the yield of milk shrank one sixth, while in richness it increased one one hundred and fiftieth; or the shrinkage was over sixteen per cent and the increase in fat less than one per cent.

These results are closely in accord with previous investigations at this station. See Bulletin No. 9, pages 12–14. In the experiments there recorded the substitution of corn meal for gluten gave a shrinkage of milk of 8.5 per cent, while the change in per cent of fat was .09 of one per cent.

EFFECT ON BUTTER PRODUCT.

At the close of each period, milk from groups 1, 2, and 4, and from Maramee of group 3, was separated with the De Laval Baby Hand Separator.

The cream was cooled to 45° F., and churned on the following day, while still sweet. Analyses of both the skim-

milk and buttermilk were made and samples of butter were reserved for future examination.

The comparative hardness of the butter was determined by Prof. C. L. Parsons, by means of the apparatus described in Bulletin No. 13—that is, by recording the depth of penetration of a glass rod dropped from a given height. The softer the butter, the further the rod will penetrate. The changes in food, such data as may be of general interest as to churnability, loss of fat in skimmilk and buttermilk, and hardness of butter are given in the following table.

The character of the butter from the different groups was practically constant with the exception of hardness. In hardness there were several sharp variations. With Princess Leto and Pilot's Lily the change from a heavy grain ration resulted in a much softer butter. With Maramee the substitution of corn meal for gluten and cotton-seed meal resulted in decidedly hardening the butter. Corn meal usually produces butter of a firm texture, but cotton-seed meal has the same tendency in a greater degree and might have been expected to balance the softening influence of gluten. It would seem probable that the very wide nutritive ratio of the ration fed in period 3 should be credited with a part of this effect. With Chinchilla, Jr., and Frost, Jr., the change to oat hay resulted in a very much softer butter. Although the butters from rations containing oat hay were generally softest, it is doubtful if the whole of the variation in this instance is traceable to it.

A study of the figures given in relation to the amount of fat lost per pound of butter recovered and the pounds of milk required per pound of butter, may be of interest. They are to a certain extent an illustration of the differences between the four breeds of cows. The approximate amount of butter from each cow can be easily calculated by reference to tables 1, 2, 3, and 4. The figures show what wide variations exist between different cows and herds.

	Period.	Ration. Ensilage, mixed grain, and —	Nutritive ratio.	Separating temperature, degree, F.	Speed of separator, revolutions per minute.	Churning temperature, degree, F.	Time churning in minutes.	Per cent of fat in skimmilk.	Per cent of fat in buttermilk.	Fat lost per pound of butter recovered.	Milk required per pound of butter.	Hardness of butter, mm. of penetration.
Duchess and Duchess, 2d.	1	Mixed and oat hay	1:6	82	6,100	48-54	15	.13	.48	.037	20 22	10.5
	2	Clover	1:5.2	88	6,500	48-54	35	.13	.52	.050	23 85	8 0
	3	Mixed hay	1:6.2	90	6,500	48-55	44	.20	.50	.061	23.91	6 0
	4	Mixed and oat hay	1:6	90	6,500	48-52	25	.08	.65	.043	23.92	9.0
Princess Leto and Pilot's Lily.	1	Mixed and oat hay	1:6	77	6,100	48-58	47	.22	.26	.036	17 75	5.0
	2	Vetch hay	1:4.7	88	6,500	52-57	35	.16	.29	.027	15.21	5 5
	3	Mixed hay and corn meal	1:6.2	90	6,500	52-58	60	.20	.23	.031	16.39	5 5
	4	Mixed and oat hay	1:6	90	6,500	52-51	49	.08	.40	.030	16.89	12 0
Maramee.	1	Mixed and oat hay	1:6	74	6,100	48-54	23	.35	.53	.115	32.05	17 0
	2	Mixed hay	1:6.2	90	6,500	48-53	30	.16	1.74	.102	30.75	18.5
	3	Corn meal in place of gluten and cotton-seed	1:9.8	90	6,500	48-54	68	.23	.40	.080	30.86	12.0
	4	Mixed and oat hay	1:6	92	6,500	48-56	82	.15	.45	.090	32 97	18 0
Chinchilla, Jr., and Frost, Jr.	1	Mixed and oat hay	1:6	76	6,100	48-56	27	.39	.41	.090	24 27	8 0
	2	Oat hay	1:5.8	88	6,500	48-54	25	.16	.52	.048	20 92	20.0
	3	Clover	1:5.2	90	6,500	48-56	45	.30	.60	.077	22.37	16 0
	4	Mixed and oat hay	1:6	92	6,500	48-56	77	.15	.65	.072	25 55	16 0

Determinations of the per cent of caseine in the milk of the cows in groups 1, 2, 4, and of Maramee of group 3, were made by Mr. E. P. Stone at the close of each period, a composite sample from the milk of the last five days in each period being used for the purpose. The results appear in the last columns of tables 1, 2, 3, and 4.

No variations that can be attributed to the character of food are found. A comparison of the different cows shows that the differences in the richness of their milk is rather more marked with reference to fat than to caseine. The following table shows the percentages of fat and caseine in the milk of the different cows during period 1, and it also shows the relative proportions of fat and caseine.

PER CENT OF FAT AND CASEINE IN PERIOD 1.

	Fat.	Caseine.	
Duchess	3.91	2.90	Ratio, 1 to .74
Duchess, 2d	4.03	2.64	" 1 to .66
Princess Leto	5.23	3.45	" 1 to .66
Pilot's Lily	5.19	3.65	" 1 to .69
Maramee	3.08	2.66	" 1 to .86
Chinchilla, Jr.	4.32	3.17	" 1 to .73
Frost, Jr.	4.02	2.96	" 1 to .74

It will be seen that low percentages of fat are accompanied with low percentages of caseine. Poor in fat means, then, poor in caseine, although in the poorest milk the amount of caseine more nearly equals the amount of fat than in the richest milk.